Int.J.Curr.Microbiol.App.Sci (2020) Special Issue-11: 63-73

EXCELLENT PUBLISHERS

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 Special Issue-11 pp. 63-73
Journal homepage: http://www.ijcmas.com

IJCMAS INTERNATIONAL JOURNAL OF CURRENT MICROBIOLOGY AND APPLIED SCIENCES SPECIAL ISSUE-11 2020
NAAS RATING-5.38
www.ijcmas.com

Original Research Article

Performance of Different Sowing Dates and Cropping Systems on Yield Attributes and Yield of Pigeonpea (*Cajanus cajan* L.) under Rainfed Condition

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A B S T R A C T

A field experiment entitled, "Performance of different sowing dates on yield attributes and yield of pigeonpea (*Cajanus cajan* L.) based cropping system under rainfed condition" was conducted at Department of Agronomy, VNMKV., Parbhani during *kharif* 2016-2017 and 2017-2018. The soil of experimental plot was deep black (vertisol) with good drainage. The experiment was laid out in split plot design with two replications. In main plot treatment four sowing dates (D_1- sowing within a week period after regular commencement of monsoon, D_2- sowing 15 days after D_1, D_3- sowing 15 days after D_2 and D_4- sowing 15 days after D_3) and in sub plot treatments four cropping system i.e. I_1-pigeonpea+soybean (2:3), I_2- pigeon pea+ pearlmillet (2:1), I_3-pigeonpea+niger (2:3) and I_4-sole pigeon pea. The net plot size is 5.4 m x 4.8 m for each treatment. The results revealed that Sowing date D_1 produced significantly higher yield attributes, seed yield, straw yield and biological yield over sowing dates D_3 and D_4 and which was followed by sowing dates D_2 during both the year of investigation and pooled results. Harvest index of pigeonpea did not show significant influence due to various treatments of sowing dates but sowing dates D_3 and D_4 recorded more HI than D_1 and D_2 sowing dates. Different pigeonpea based cropping systems evaluated under research investigation improved the yield attributes, seed yield, straw yield and biological yield of pigeonpea. The seed yield of sole pigeonpea (I_4) found significantly superior over pigeonpea + soybean (I_1) pigeonpea + pearlmillet (I_2), pigeonpea + niger (I_3) during both the years of experimentation and pooled results. Similar trend was found in respect of straw yield and biological yield of pigeonpea. Harvest index of pigeonpea did not reach the level of significance in different cropping system treatments during both the years of research work. Pigeonpea + soybean cropping system gives more harvest index than rest of the cropping system during 2016. During 2017 it was observed in pigeonpea + pearlmillet cropping system.

Keywords

Cropping systems, Dates of sowing, Pigeonpea, Yield

Introduction

Climate is the basis for crop adaption. The farmer selects a crop that is adapted to the area where it will be grown. However, it is weather in the locality that will eventually determine the crop growth, development and productivity. Unless the crop and cultivars are well adapted to the area where they are grown, there cultivation in that area is uneconomical. Knowledge of agrometeorology is necessary for crop production as it is concern with interaction between meteorological and hydrological factor on one hand and crop production on the other. Weather during the crop season strongly influence crop growth and development and it accounts for 2/3 (67 %) of variation in productivity while other factors including soil and nutrient management account for 1/3 (33%). of the productivity. Importance of weather assumes greater importance in dryland agriculture where soil moisture during crop season is highly variable and strongly dependent on the quantum and distribution of rainfall. Indian agriculture, to large extent, depends on the South-West monsoon activity and associated weather condition. The agro-climatic conditions control the choice and productivity of crop and sustainability of production. Annual rainfall of the country is about 4 x 10^3 km^3 (400 M ha m) out of 5 x 10^5 km^3 received globally (Lal, 1994). India's share thus is about one per cent of global precipitation. Major contribution from South West monsoon (74 %) compared with 10 per cent during North East monsoon. The average annual rainfall of the country is 1200 mm (400 M ham). However distribution across the country varies from less than 100 mm in Western Rajasthan to greater than 3600 mm in North Eastern states and 1000 mm from East Coast to 2500- 3000 mm in West Coast. Over Indian continent, monsoon sets in either by the end of May or early June along Malabar Coast. Normal onset of monsoon over India is first June with heavy rains over Kerala and Coastal Karnataka. The earliest and most delayed one during last 100 years differ by 46 days (7 May and 22 June, respectively). In general the active phase of monsoon in India is July to September. Prolonged break in monsoon have tendency to occur during August- September break period of 6 to 8 weeks is not uncommon. Nearly 16 per cent of geographical area in the country is chronically drought affected due to prolonged breaks on monsoon. Dryland agriculture has distinct place in Indian agriculture, occupying around 67 percent of cultivated area, containing to nearly 44 per cent of food grains and supporting 40 per cent of human and 60 per cent of livestock population. Most (80 to 90 per cent) of the pulses, oilseeds and millets are confined to dryland ecosystem. It is characterized by resource poor, small and marginal farmers, poor infrastructure and low investment in technology and inputs. The mismatch between rainfall distribution and the crop water needs is the major cause of instability of certain crops in some dryland area. Most dryland areas of India are either mono-cropped or intercropped. Traditional dryland cropping systems are not necessarily the most suitable ones to the agro-climatic conditions as they are mostly subsistence systems. In agriculture management practices are usually formulated for individual crops. However, farmers are cultivating different crops in different season, domestic needs and profitability. A cropping system refers to a set of crop systems, making up the cropping activities of farm system. Cropping system comprises all the components required for production of a particular crop and the interrelationships between them and environment (TAC, CGIAR 1978). In other words, a cropping system usually refers to a combination of crop in time and space. Combination in time occurs when crops occupy different growing period and combinations in space occur when crops are inter-planted. Intercropping includes alley cropping, strip cropping, counter cropping, paired raw cropping, skip cropping, parallel cropping, companion cropping, multi-story cropping and synergetic cropping (additive series and replacement series). Cereals with pigeonpea intercropping systems are popular in India (Aiyer, 1949). Amount of rainfall determines the cereal crop associated with pigeonpea, rice with 1000 to 1500 mm, maize with 750 to 1000 mm, sorghum with 500 to 750 mm and millets with 400 t0 600 mm rainfall. Most cereals, depending on their growth duration and height, reduce the growth of pigeonpea and can be ranked for competitiveness: maize > sorghum > pearlmillet >setaria (Rao and Willey, 1980). At IARI (New Delhi), pearlmillet and pigeonpea in 2:1 (40/80 cm paired row planting) as additive series resulted in highest yield and economic advantage during rainy season (Ramulu *et al.,* 1998). Paired raw planting can accommodate full population of base crop and leave adequate inter space to accommodate two or more raw of intercrop. In this technique two adjacent rows of the base crop are paired reducing the inter-row spacing in the pair, narrow enough to create some inter-space between pairs of base crop rows but wide enough to minimize competition among plants of the base crop. In the inter-space of 60 cm, one raw of pigeonpea or two or more rows of other short statured intercrop can be planted. In other words, two rows of base crop and three rows of intercrop can be accommodated in 90 cm space instead of two rows of base crop alone with usual planting method. This is often referred to as 30/60 cm paired row planting. In dryland agriculture, intercropping is practiced to minimize the risk of total crop failure due to rainfall vagaries than for yield and economic advantage over sole cropping. All India coordinated research project on cropping systems indicated several intercropping systems in different region of the country in the recent past (Hegde, 1992, Singh *et al.,* 1994, Yadav and Prasad, 1997)**.** Pigeonpea is a highly drought resistant crop. It can successfully grown in areas receiving only 65 cm annual rainfall, as the crop matures fast and pest damage is low. It is mostly photoperiodic sensitive and short days result in reduced vegetative phase and onset of flowering. Pigeonpea can be cultivated on variety of soils from sand to heavy clay loams. However, well drained medium heavy loams are best suited. The inbuilt mechanism of biological nitrogen fixation enables pulse crops to meet 30 to 90 % of their N requirements, hence a small dose of 15- 25 kg N/ha applied at sowing is sufficient to meet the requirement of most of the pulse crops (Karwasra and Anil Kumar, 2007). Pigeonpea can be knitted into many cropping systems, viz. intercropping, mixed cropping and sequential cropping etc. The initial slow growth, deep rooting pattern, ability to tolerate drought and low soil moisture has made it highly suitable crop for intercropping systems. It is intercropped with many short duration legumes, cereals and commercial crops. With the complementary effect of pigeonpea on soil fertility, improvement, nutrient recycling, smothering of weeds and efficient utilization of soil moisture under different cropping systems it occupies more area in cropping systems than as a sole crop.

Materials and Methods

The field experiment was conducted during the rainy season (*kharif)* 2016 and 2017 at Agronomy Farm, College of Agriculture, Parbhani (Maharashtra). The soil was clayey in texture with pH 7.85. The soil was low in organic carbon (0.50%), low in available nitrogen (198.00 kg/ha), medium in phosphorus (14.26 kg/ha) and high in potash (492.60 kg/ha). The experiment consisted of 16 treatment combinations of 4 sowing dates ((D_1- sowing within a week period after regular commencement of monsoon, D_2- sowing 15 days after D_1, D_3- sowing 15 days after D_2 and D_4- sowing 15 days after D_3) and 4 cropping system treatments i.e. I_1- pigeonpea+soybean (2:3), I_2- pigeon pea+ pearlmillet (2:1), I_3-pigeonpea+niger (2:3) and I_4-sole pigeon pea in sub-plot was laid out in split-plot design and replicated 2 times. The gross and net plot size was taken 6.6 m x

6.0 m and 5.4 m x 4.8 m respectively. Pigeonpea variety 'BDN 711', soybean 'MAUS 71', pearlmillet 'ABPC 4-3' and 'PNS 6' were sown on 27 June 2016 and 24 June 2017 as first sowing date (D_1) and D_2, D_3 and D_4 sowing was done after 15 days interval between each sowing date respectively. The seeds were sown in 60 cm x 20 cm spacing for pigeonpea, 30 cm x 15 cm for soybean and niger and 60 cm x 15 cm for pearlmillet. In intercrop situation, pigeonpea was sown in paired rows at 60 cm keeping 120 cm distance between 2 pair to adjust 3 rows of intercrop for soybean and niger (2:3) and 1 row (2:1) for pearlmillet (60/120 cm). The plant-to-plant distance of 20 cm in pigeonpea and 15 cm in intercrops was maintained. The recommended seed rates of 12-15 kg ha^{-1}, 60-65 kg ha^{-1}, 4-5 kg ha^{-1} and 3-4 kg ha^{-1} of pigeonpea, soybean, pearlmillet and niger crops were used in the experiment. The recommended dose of 25 kg N/ha through urea and 50 kg P_20_5/ha through single superphosphate was applied to sole pigeonpea as well as in pigeonpea cropping systems as a basal application. To maintain healthy and good crop stand follow the all recommended package of practices like thining, weeding and plant protection measures as and when required. The experimental data obtained on various selected variables were analyzed by the standard method of statistical analysis (Panse and Sukhatme, 1967).

Results and Discussions

Yield attributes and yield

Sowing dates: Improvement in various growth parameters thereby increased photosynthetic efficiency of pigeonpea which led to higher assimilate production and their efficient partitioning to the economic sink. Sowing date (D_1) recorded significantly superior number of pods plant^{-1} (164.88 and 168.25 at harvest) and was at par with D_2 (146.75 and 158.25) than other sowing dates (D_3 and D_4) during both the years. The reason behind that the high number of branches gave scope for more inflorescence and that indicated through high number of pods plant^{-1}. Earlier sowing produced longer pods that accommodated significantly more seeds pod^{-1} and also produced the cumulative factors resulted in higher yields. The late sowing reduced significantly, all these growth and yield components due to the fact that late planting coupled with early maturity did not allow enough time for vegetative growth and subsequently, there was decrease in pod formation period and thus reduced grain yield (Sharma *et al.*, 2014). Number of pods plant^{-1}, weight of pods plant^{-1}, weight of seeds plant^{-1}, number of seeds plant^{-1}, number of seeds pod^{-1} and 100 seed weight (seed index) of pigeonpea were closely related with each other and positively correlated with total seed yield plant^{-1}. First sowing date (D_1) during both the seasons improved the weight of pods, number and weight of seeds plant^{-1} with the increase in total number of pods plant^{-1}. The improvement in the yield attributes might be due to increased growth parameters in first and second sowing dates than delayed sowings. In first year of investigation for mean number of seeds pod^{-1} (3.18) in sowing date (D_3) was observed significantly superior over rest of the dates. Sowing date (D_1) recorded significantly superior number of seeds pod^{-1} (3.75) over sowing dates D_2, D_3 and D_4 during second year of investigation. The 100-seed weight (seed index) of pigeonpea was found higher with delayed sowing during both the year. Kumar *et al.*, (2008) also reported the higher test weight of pigeonpea at late sowing. But the 100 seed weight did not differ significantly due to different sowing dates. Such effects of sowing dates on pigeonpea have also been reported earlier by Pramila Rani and RajiReddi (2010), Hari Ram *et al.*,

(2011) and Malla Raddy *et al.,* (2012). Data on seed yield (kg ha^{-1}) of pigeonpea revealed that there was significant influence of different sowing dates during both the years of study and in pooled analysis. During both the year of investigation, sowing date (D_1) produced 1801 and 1831 kg ha^{-1} of seed yield of pigeonpea, respectively and it was significantly higher than (D_3 and D_4) but equivalence with sowing date (D_2) (1684 and 1708 kg ha^{-1}). In pooled analysis, similar trend was continued. As a result of cumulative effect of better growth, more dry matter accumulation and improvement in yield components and ultimate total seed yield (kg ha^{-1}) was enhanced due to effect of sowing dates (D_1 and D_2). The early sown recorded higher growth parameters like plant height, total DMP, haulm yield, number of pods, weight of seed $plant^{-1}$ but less harvest index due to more vegetative growth as compare to late sowing dates. Rajput and Yadav (1998) reported maximum seed yield with the crop sown on 10 July as compared to 20 and 30 June and 20 July. Very late sown crop recorded lower number of branches, number of pods per plant and seed weight than all other dates and hence recorded lower seed yield. Similarly, Rani and Reddy (2010) obtained significantly higher yield of pigeonpea when it was sown during the last week of July compared to delayed sowing. The increased seed yield due to early sowing is ascribed to the high LAI and its persistence, PAR interception and absorption leading to higher dry matter accumulation before the crop reached the reproductive stage (Patel *et al.,* 1997). Under late sown conditions, the plant however could not accumulate sufficient photosynthates due to short vegetative growth period, hence less stronger sink. Since pigeonpea is a thermo sensitive crop, delayed sowing had a marked influence on both seed and total biomass in 2016-17 and 2017-18. The highest seed yields and biomass were obtained with the earliest sowing. Maximum seed yield and biomass under early sowing were attributed to the persistence of a larger canopy cover and light interception, coinciding with the late reproductive phase when pod number had been determined. Successive delays in sowing substantially decreased seed yields and biomass, probably because the late sown crop absorbed less PAR and accumulated less dry matter as a consequence of reduced leaf area and phonological potential. These results are in conformity with those reported by Channabasavanna *et al.*, (2015), Balai *et al.*, (2013), Hari Ram *et al.*, (2011) Patel *et al.*, (1997) Stalk yield ($kgha^{-1}$) and biological yield (kgha1) of pigeonpea showed similar trend as that of seed yield(kgha-1)of pigeonpea. The higher Stalk yield ($kgha^{-1}$) and biological yield ($kgha^{-1}$) of pigeonpea was recorded in sowing dates D1 than sowing dates D3 and D4 but which was at par with D2. Harvest index of pigeonpea did not show any significant differences due to different date of sowing during both the years of investigations. But in late sown crop gives more harvest index (D3 and D4). Seijoon *et al.,* (2000) also found similar results and suggested that the increased harvest index with late sown crop could be related to high assimilate use efficiency due to increased sink capacity (Table 1).

Influence of cropping systems

Information regarding the effect of intercropping systems on yield attributes and yield of pigeonpea has been discussed under different sub-heads.

Yield attributes and yield: Yield attributes such as number of pods $plant^{-1}$, weight of pods, and weight of, number of seeds $plant^{-1}$, number of seeds pod^{-1} and 100 seed weight (seed index) were significantly influenced by different cropping systems in pigeonpea during both the years of experimentation. The deviation observed due to cropping system in respect of mean number of pods plant^{-1} of pigeonpea were found significant at 120, 150 and at harvest growth stages of crop during both the seasons under study. The cropping system pigeonpea + soybean (I_1) found significantly superior mean number of pods plant^{-1} i.e. 147.75 and 153.63 at harvest stage over pigeonpea + pearlmillet (I_2), pigeonpea + niger (I_3) and sole pigeonpea (I_4) during both the years of experimentation. But the different cropping systems significantly reduced the number of pods plant^{-1}, seed yield plant^{-1} and thus yield ha^{-1}of pigeonpea. The highest reduction in yield and yield components was noticed when pigeonpea was intercropped with pearlmillet and niger than soybean. Also pigeonpea + Soybean planted in 2:3 row proportion may indicate less interplant competition that allows more growth of plants producing more branching. It was mainly due to their greater competitive nature for growth resources in other intercropping. Soybean as a intercrops being of short duration and short statured did not cause much competition with pigeonpea. These results are in conformity with the findings of Goyal *et al.,* (1991), Singh and Singh (1994) and Rathod *et al.,* (2004). Weight of pods, weight of seeds plant^{-1}, number of seeds plant^{-1} and number of seeds pod^{-1} were closely related with each other and positively correlated with total yield plant^{-1}. During both the seasons, weight of pods, weight of seeds and number of seeds plant^{-1} increased with the increase in total number of pods due to different cropping systems. The improvement in the yield attributes might be due to increased availability of more space, more light interception, nutrients and moisture due to less competition between plants which favoured more number of branches and number pods plant^{-1}. Such effects of spacing in pigeonpea have also been reported earlier by Rathod *et al.,* (2004). The difference observed due to cropping system in respect of mean number of seeds pod^{-1} of pigeonpea were found significant at harvest stages of crop during both the years of experimentation. The pigeonpea + soybean (D_1I_1) found significantly superior mean number of seeds pod^{-1} i.e. 3.05 and 3.50 over pigeonpea + niger (D_1I_3) and sole pigeonpea (D_1I_4) and on par with pigeonpea + pearlmillet (3.10 and 3.53) (D_1I_2) during both the years of experimentation respectively. During both the year's 100 seed weight did not differ due to various cropping systems. This might be due to minor effect of cropping system on pod morphology. Also seed size is genetical character it does not produce much effect due to environmental conditions. As the growth and yield components of pigeonpea were influenced by different cropping system treatments, an improvement in seed yield, straw yield and biological yield was observed during both the seasons and in pooled analysis. The deviations observed due to cropping system in respect of seed yield (kg ha^{-1}) of pigeonpea were found significant during both the years of experimentation and in the pooled results. The seed yield of sole pigeonpea (I_4) i.e. 1924, 1839 and 1876 kg ha^{-1} found significantly superior over pigeonpea + soybean (I_1) pigeonpea + pearlmillet (I_2), pigeonpea + niger (I_3) during both the years of experimentation and pooled results. The straw yield of sole pigeonpea (I_4) i.e. 5510, 6735 and 6123 kg ha^{-1} found significantly more over pigeonpea + soybean (I_1) pigeonpea + pearlmillet (I_2), pigeonpea + niger (I_3) during both the years of experimentation and pooled results. The biological yield of sole pigeonpea (I_4) in 2016-17, 2017-18 and pooled results were 7434, 8575 and 8004 kg ha^{-1} found significantly higher over pigeonpea + soybean (I_1) pigeonpea + pearlmillet (I_2), pigeonpea + niger (I_3) (Table 2).

Table.1 Yield attributes of pigeonpea as influenced by dates of sowing and cropping systems during 2016 and 2017

Treatments	Number of pods plant^{-1}		Weight of pods (g)		Weight of seeds (g)		Nu. of seeds plant^{-1}		Nu. of seeds pod^{-1}		Seed index (g)	
	2016	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**
A) DOS												
D_1	164.88	168.25	61.75	65.63	39.88	43.75	500.88	629.38	3.03	3.75	8.88	8.43
D_2	146.75	158.25	57.38	57.00	38.75	39.50	438.00	544.13	3.00	3.43	8.83	8.17
D_3	134.94	135.00	49.88	47.00	32.38	33.13	368.43	450.63	2.73	3.33	8.74	7.81
D_4	88.63	84.13	37.00	30.75	24.88	18.63	285.00	251.25	3.18	2.93	9.30	9.31
S.E. (m)	3.96	4.51	1.31	1.88	0.82	1.26	11.12	19.59	0.02	0.05	---	---
C.D. (0.05)	18.45	21.08	6.10	8.74	3.82	5.88	51.85	91.32	0.11	0.23	---	---
B) CS												
I_1- PP+SOY	147.75	153.63	57.75	57.88	37.38	39.13	445.00	548.25	3.05	3.50	9.10	8.73
I_2-PP+PM	135.75	138.50	52.75	51.75	35.00	35.00	414.50	492.38	3.10	3.53	9.05	8.12
I_3- PP+ NI	126.38	128.50	47.75	46.00	31.00	30.00	361.80	427.88	2.80	3.12	8.89	8.63
I_4- SOLE PP	125.31	125.00	47.75	44.75	32.50	30.88	371.00	406.88	2.98	3.28	8.71	8.37
S.E. (m)	0.88	1.10	0.35	0.47	0.24	0.28	2.98	5.40	0.02	0.02	---	---
C.D. (0.05)	2.73	3.43	1.09	1.45	0.75	0.89	9.28	16.82	0.06	0.06	---	---
C) D X I												
S.E. (m)	4.24	4.90	1.44	2.04	0.92	1.35	12.26	21.71	0.04	0.06	---	---
C.D. (0.05)	18.92	21.67	6.33	9.02	3.99	6.03	53.80	94.95	0.15	0.25	---	---
GM	**133.80**	**136.41**	**51.50**	**50.09**	**33.97**	**33.75**	**398.08**	**468.84**	**2.98**	**3.36**	**8.94**	**8.43**

Table.2 Seed yield (kg ha^{-1}), straw yield(kg ha^{-1}), biological yield (kg ha^{-1}) and harvest index (%) as influenced by dates of sowing and different cropping systems during 2016-17, 2017-2018 and pooled

Treatments	Seed yield (Kg ha^{-1})			Straw yield (Kg ha^{-1})			Biological yield (Kg ha^{-1})			Harvest index (%)		
	2016	**2017**	**Pool**	**2016**	**2017**	**Pool**	**2016**	**2017**	**Pool**	**2016**	**2017**	**Mean**
A) DOS												
D_1	1801	1861	1831	5137	5772	5455	6938	7633	7286	26.50	25.50	26.50
D_2	1684	1708	1696	4248	4841	4545	5932	6549	6241	29.00	27.88	29.00
D_3	1408	1400	1404	2895	3436	3165	4303	4836	4570	33.75	30.63	33.75
D_4	1115	1130	1117	2479	2547	2513	3594	3677	3635	31.00	30.63	31.00
S.E. (m)	31	39	34	147	172	159	183	211	197	---	---	---
C.D. (0.05)	143	182	158	685	803	743	851	985	917	---	---	---
B) CS												
I_1- PP+SOY	1590	1521	1555	3419	3495	3457	5009	5015	5012	32.75	30.75	32.75
I_2-PP+PM	1343	1469	1406	3091	3308	3200	4434	4777	4605	30.63	31.00	30.63
I_3- PP+ NI	1152	1271	1211	2739	3058	2898	3890	4329	4110	30.25	29.75	30.25
I_4- SOLE PP	1924	1839	1876	5510	6735	6123	7434	8575	8004	26.63	23.13	26.63
S.E. (m)	17	14	13	79	116	96	97	128	112	---	---	---
C.D. (0.05)	53	45	42	245	360	300	303	397	348	---	---	---
C) D X I												
S.E. (m)	42	46	41	200	264	231	249	306	276	---	---	---
C.D. (0.05)	166	195	171	781	997	889	982	1178	1076	---	---	---
General Mean	**1502**	**1525**	**1512**	**3690**	**4149**	**3919**	**5192**	**5674**	**5433**	**30.06**	**28.66**	**30.06**

The increase in seed, straw yield and biological yield was observed in sole pigeonpea (I_1) might be due to higher growth rate of pigeonpea under sole planting, also spacing (60 cm x 20 cm i.e. 83333 plants ha^{-1}) helped for better light interception by crop coupled with high plant population as compared to other cropping system planted in paired row (60-120 cm) having less plant population ha^{-1} (i.e. 55555 plants ha^{-1} which was 1/3 less than sole population). These results are in agreement with the research findings of Sonawane *et al.,* (2011) and Singh *et al.,* (2017). The total production per ha of land from the intercropping system was more compared to sole cropping of either pigeonpea, pearlmillet or niger. It therefore suggests that the land resources from each unit area are efficiently utilized. Roy *et al.,* (2016) obtained higher total production in pigeonpea based intercropping systems. Venkateswaralu (1986) also reported that the total production per unit area of land increased with intercropping system over sole crops. However, higher productivity from the system alone cannot be a yard stick to measure the advantages but it is finally the monetary returns that count for acceptability of the system (Itnal *et al*., 1994).

Harvest index did not showed significant difference in pigeonpea during both the seasons of experimentation. Harvest index of pigeonpea did not show any significant differences in different cropping system treatments during both the years of research work. Intercropped pigeonpea recorded more harvest index than sole crop only during both the year of experimentation (Pramila Rani and Raji Raddy, 2010). Here pigeonpea + soybean cropping system gives more harvest index than rest of the cropping system during 2016-17. During 2017-18 it was observed in pigeonpea + pearlmillet cropping system. This was due to higher sink capacity in intercropping system as compared to sole pigeonpea crop.

In conclusion, sowing date D_1 produced significantly higher yield attributes, seed yield, straw yield and biological yield than sowing dates D_3 and D_4 and which was followed by sowing dates D_2 during both the year of investigation. Harvest index of pigeonpea did not show significant influence due to various treatments of sowing dates but sowing dates D_3 and D_4 recorded more HI than D_1 and D_2 sowing dates. Different pigeonpea based cropping systems evaluated under research investigation improved the yield characters, seed yield, straw yield and biological yield of pigeonpea. The seed yield of sole pigeonpea (I_4) found significantly superior over pigeonpea + soybean (I_1) pigeonpea + pearlmillet (I_2), pigeonpea + niger (I_3) during both the years of experimentation and pooled results. Similar trend was found in respect of straw yield and biological yield of pigeonpea. Harvest index of pigeonpea did not reach the level of significance in different cropping system treatments during both the years of research work. Pigeonpea + soybean cropping system gives more harvest index than rest of the cropping system during 2016. During 2017 it was observed in pigeonpea + pearlmillet cropping system.

References

Aiyer A.K.Y.N. 1949. Mixed cropping in India. *Indian Journal of Agriculture Sciences.* 19:39-443

Balai, L. P., R. B. Singh and Yadav, S. M. 2013. Sowing Time and Plant Population on the Disease Intensity of Alternaria Blight of Pigeonpea. *Indian Journal of Plant Protection*. 41(4): 326-331.

Channabasavanna, A. S., M. S. Kitturmath and Rajakumar, H. 2015. Standardization of sowing date and genotypes of pigeonpea [*Cajanus cajan* (L.) Mill sp.] under erratic rainfall conditions in northern dry zone of Karnataka. *Karnataka J. Agric. Sci.* 28(4):604-605.

Goyal, S. N., N. L. Patel, N.M. Patel, and Ahlawat, I.P.S. 1991. Intercropping studies in pigeonpea under rainfed conditions. *Indian Journal of Agronomy*. 36:49-51.

Hari, R., G. Singh, H.S. Sekhon and Veena Khanna. 2011. Effect of sowing time on the performance of pigeonpea genotypes. *Journal of Food Legumes*. 24(3): 207-210.

Hegde, D. M. 1992. Cropping systems research highlights. Bulletin PDCSR, Modipuram, Meerut, India.

Itnal, C. J., V. P. Nagalikar, B.S. Ligaraju and Basavaraj, P.B. 1994. Intercropping pigeonpea with pearl millet in north eastern dry zone of Karnataka. *Karnataka J. Agric. Sci. 7(1)6-9.*

Karwasra, R. S. and Anil Kumar. 2007. Response of pigeonpea (*Cajanus cajan* L.) to NPK in Haryana. *Haryana Journal of Agronomy*. 23 (1/2): 117

Lal, R. 1994. Water management in various crop production systems related to tillage. *Soil and Tillage Research*. 30: 169-185.

Mall, R.K., M. Lal, V.S. Bhatia, L.S. Rathore and Singh, R. 2004. Mitigating climate change impact on soybean productivity in India: a simulation study. *Agricultural and Forest Meteorology*.121:113–125.

Panse, V. G. and Sukhatme, P. V. 1967. Statistical methods for agricultural workers. ICAR, New Delhi. pp. 381.

Patel, N. R., Mehta, A. N. and Shekh, A. M. 1997. Effect of sowing date and row spacing on phenology and yield of two diverse genotypes of pigeonpea (*Cajanus cajan*). *Indian Journal of Agricultural Sciences*. 6(4): 153-156.

Pramila, R., B. and Reddy, D. R. 2010. Performance of pigeonpea in sole and inter cropping system in vertisols of Krishna - Godavari zone in Andhra Pradesh. *Indian J. Agric. Res*. 44 (3): 225–228.

Rajput, R. L. and Yadav, K. S. 1998. Bhartiya Krishi Anusandhan Patrika. 13: 161-164.

Ramulu V., R.C. Gautam and Kaushik, S.K. 1998. Intercropping in pearlmillet with grain legumes and oilseed crop under *rainfed* conditions. *Indian Journal of Agronomy*.43: 82-386.

Rao, M. R. and Willey, R.W. 1980. Preliminary studies on intercropping combinations based on pigeonpea or sorghum. *Experimental Agriculture.* 16: 29-40

Rathod, P. S., S. I. Halikatti, S.M. Hiremath and Kajjidoni, S.T. 2004. Influence of Different Intercrops and Row Proportion on Growth and Productivity of Pigeonpea in Vertisols of Dharwad. *Karnataka J. Agric. Sci.* 17(4): 647-651.

Seijoon, P., K. Wookhan and Rakehun, S. 2000. Influence of different planting times on harvest index and yield determination factors in soybean. *Korean Journal of Crop Science*. 45: 97-102.

Sharma, A., M. Sharma, K. C. Sharma, Y. Singh, R. P. Sharma, and Sharma, G. D. 2014. Standardization of sowing date and cultivars for seed production of garden pea (*Pisum sativum* var. Hortense l.) under north western Himalayas. *Legume res.* 37(3): 287-293.

Singh M. and Lal, B. 1994. Grain yield and economic returns under varying crop sequences under varying levels of rainy season and winter season irrigations. *Indian Journal of Agronomy*.39:211-215

Singh, D., R. Singh, R. L. Baghel, Rajput and Rai A. K. 2017. Effect of different age of seedlings and planting geometry on yield attributes and yield of transplanted pearlmillet (*pennisetum glaucam*). Bhartiya Krishi Anushandhan Patrika. 32(2): 85-86.

Sonawane, D. A., S. S. Tithe, T. M. Bahale and Dalavi, N. D. 2011. Evaluation of pigeonpea based intercropping systems under scarcity condition of *Northern Maharashtra. JNKVV Research Journal*. 45(1): 81-84.

TAC CGIAR. 1978. Farming systems research at International Agricultural Research Centers, Rome, Italy.

Venkateswaralu, S. 1986. Intercropping pigeonpea with short duration pulses in Semi-Arid Alfisols. *Indian Journal of Dryland Agricultural Research and Development.* 1: 48-55.

Yadav R. L. and Prasad, K. 1997. Efficient farming systems. *Indian Farming.* 47: 30-35.